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Effect of live weight gain of steers during winter grazing: I. Feedlot performance, carcass characteristics, and body composition of beef steers[1,2,3]

M. J. Hersom*, G. W. Horn*[4], C. R. Krehbiel*, and W. A. Phillips†

*Department of Animal Science, Oklahoma State University, Stillwater, 74078 and †USDA, ARS Grazinglands Research Laboratory, El Reno, OK 73036

ABSTRACT: Two experiments were conducted to examine the effect of previous BW gain during winter grazing on subsequent growth, carcass characteristics, and change in body composition during the feedlot finishing phase. In each experiment, 48 fall-weaned Angus × Angus-Hereford steer calves were assigned randomly to one of three treatments: 1) high rate of BW gain grazing winter wheat (HGW), 2) low rate of BW gain grazing winter wheat (LGW), or 3) grazing dormant tallgrass native range (NR) supplemented with 0.91 kg/d of cottonseed meal. Winter grazing ADG (kg/d) for HGW, LGW, and NR steers were, respectively, 1.31, 0.54, 0.16 (Exp. 1) and 1.10, 0.68, 0.15 (Exp. 2). At the end of winter grazing, four steers were selected randomly from each treatment to measure initial carcass characteristics and chemical composition of carcass, offal, and empty body. All remaining steers were fed a high-concentrate diet to a common backfat end point. Six steers were selected randomly from each treatment for final chemical composition, and carcass characteristics were measured on all steers. Initial fat mass and proportion in carcass, offal, and empty body were greatest ($P < 0.001$) for HGW, intermediate for LGW, and least for NR steers in both experiments. Live BW ADG and gain efficiency during the finishing phase did not differ ($P = 0.24$) among treatments, but DMI (% of mean BW) for NR and LGW was greater ($P < 0.003$) than for HGW steers. Final empty-body composition did not differ ($P = 0.25$) among treatments in Exp. 1. In Exp. 2, final carcass and empty-body fat proportion (g/kg) was greater ($P < 0.03$) for LGW and NR than for HGW steers. Accretion of carcass fat-free organic matter was greater ($P < 0.004$) for LGW than for HGW and NR steers in Exp. 1, but did not differ ($P = 0.22$) among treatments in Exp. 2. Fat accretion in carcass, offal, and empty body did not differ ($P = 0.19$) among treatments in Exp. 1, but was greater ($P < 0.05$) for LGW and NR than for HGW steers in Exp. 2. Heat production by NR steers during finishing was greater ($P < 0.02$) than by HGW steers in Exp. 1 and 2. Differences in ADG during winter grazing and initial body fat content did not affect rate of live BW gain or gain efficiency during finishing. Feeding steers to a common backfat thickness end point mitigated initial differences in carcass and empty-body fat content. However, maintenance energy requirements during finishing were increased for nutritionally restricted steers that were wintered on dormant native range.

Key Words: Body Composition, Cattle, Feedlot Performance, Winter Grazing

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Introduction

Beef cattle backgrounding and growing programs can have profound effects on body composition (Carstens et al., 1991), nutrient metabolism (Thomson et al., 1982),

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[3]Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.

[4]Correspondence: 208 Animal Science Bldg. (phone: 405-744-6621; fax: 405-744-7390; e-mail: horngw@okstate.edu).

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and subsequent feedlot performance (Drouillard et al., 1991a). Sainz et al. (1995) reported that changes in body composition through previous nutrition resulted in decreased or increased maintenance energy requirements of growing cattle depending on type of diet and feed intake. It is generally considered that growth rate and efficiency of finishing cattle decrease as initial body fat or body condition increases (Mies, 1992). Metabolizable energy allowable daily gain of growing/finishing cattle at a given BW, as predicted by the Level 1 Model (NRC, 1996), decreases as initial body fat content increases.

Previous nutrition that restricts cattle growth and limits body fat deposition can positively affect cattle performance in the feedlot through increased growth. Altering previous nutrition has also been reported to affect composition of BW gain in the feedlot (Fox et al., 1972; Rompalla et al., 1985). Much of the previous work examining feedlot growth has utilized different intake levels of concentrate or forage-based diets during the growing phase rather than specific grazing programs. Growing cattle on winter wheat pasture is a major beef cattle production program in the southern Great Plains. However, variation in BW and body condition of these cattle when placed on feed is very large. We hypothesized that steers of similar genetics with different BW gains and body composition resulting from winter grazing programs would exhibit different growth rates in the feedlot and have different rates of accretion of protein and lipid during finishing. Therefore, our objectives were to compare the effect of previous BW gain resulting from winter grazing programs on subsequent feedlot performance, carcass characteristics, and change in body composition during the finishing phase of production.

Materials and Methods

Animals and Management

In each of two experiments, 48 fall-weaned Angus × Angus-Hereford steers (244 ± 23 kg initial BW, 268 ± 26 d of age, Exp. 1, and 231 ± 25 kg initial BW, 272 ± 24 d age, Exp. 2) from the same cowherd were allotted randomly to one of three winter grazing programs. The grazing programs consisted of grazing hard red winter wheat pasture (*Triticum aestivum*, '2174') to achieve either a high (**HGW**) or low (**LGW**) rate of BW gain, and grazing dormant tallgrass native range (**NR**). The HGW and LGW steers were placed on a single wheat pasture at a stocking density of 4.9 steers/ha for an initial 7- to 10-d grazing period in order to rapidly decreased forage mass. After this initial grazing period, LGW steers (2.45 steers/ha) remained on the pasture and HGW steers were moved to an adjacent wheat pasture of 14.6 ha (1.1 steers/ha). These initial stocking densities for HGW and LGW steers were adjusted throughout the wheat pasture grazing period by varying the size of each pasture. The steers grazed each pasture continuously, and the height of the available forage for HGW steers was always in excess (15 to 20 cm), whereas it was limited and often less than 5 cm in height for LGW steers. The NR steers were placed on a 48.6-ha dormant tallgrass native range pasture (big bluestem; *Andropogan gerardii* Vitman, little bluestem; *Achizachyrium scoparium* [Michx.] Nash, indiangrass; *Sorgastrum nutans* [L.] Nash, and switchgrass; *Panicum virgatum* L.) and were offered 0.91 kg/d of cottonseed meal (41% CP). Steers were not implanted during winter grazing. In Exp. 1, grazing was initiated on December 7, 1999 and terminated on April 6, 2000, after 120 d. In Exp. 2, grazing was initiated on December 18, 2000 and was terminated on May 10, 2001, after 144 d. Body weights were obtained after withholding steers from forage and water for 5 to 6 h on all weigh dates: the initiation of grazing, monthly during grazing, and at the termination of grazing.

Before entering the feedlot, steers were commingled and allowed access to hay for 3 d to minimize differences in digestive tract fill. Steers were then held without feed and water for 5 to 6 h (Exp. 1), or transported to the USDA, ARS Grazinglands Research Laboratory, El Reno, OK (Exp. 2), and weights were taken before placement into feedlot pens. Steers were stratified by weight within winter grazing program and assigned to feedlot pens to minimize the range of BW within a pen. All steers were implanted with Revalor-S (24 mg of estradiol, 120 mg of trenbolone acetate; Intervet; Millsboro, DE) and vaccinated for infectious bovine rhinotracheitis, bovine virus diarrhea, parainfluenza-3, and respiratory syncytial virus (Titanium 5, Diamond Animal Health; Des Moines, IA). In Exp. 1, steers were fed in 12.2- × 30.5-m open pens at the Willard Sparks Beef Research Center, Stillwater, OK (three pens/treatment, four steers/pen). In Exp. 2, steers were fed individually by use of the Calan Broadbent Feeding System (American Calan; Northwood, NH) in 4.57-m^2 pens in an open-fronted building. During both experiments, steers were adapted over 4 wk to the final feedlot diet (Table 1) by replacing cottonseed hulls in Exp. 1 or ground alfalfa hay in Exp. 2 with corn. After adaptation to the final diet, in Exp. 1 steers were offered sufficient feed twice daily at 0800 and 1300 for the bunks to have approximately 2.5 kg at 2100 and no feed at 0700 the following morning. In Exp. 2, all steers were offered ad libitum access to feed and were fed once daily at 0800; one steer was removed from the HGW treatment because of a failure to train to eat from the Calan headgate. During the feedlot phase, steers were weighed unshrunk at monthly intervals, and were fed to a common end point of 1.27 cm of backfat as determined by ultrasound (Model 210; probe, Model UST-5021; Aloka Co. Ltd., Wallingford, CT) between the 12th and 13th rib on the right side. When average backfat of the treatment reached 1.27 cm, all steers were slaughtered within 9 d. The Oklahoma State University Institutional Animal Care and Use Committee approved the use of animals and research protocols.

Table 1. Composition of the final feedlot diets

Item	Experiment 1	Experiment 2
Ingredient, % of DM		
Dry whole-shelled corn	70.9	—
Dry-rolled corn	—	82.6
Cottonseed hulls	9.0	—
Ground alfalfa hay	—	8.0
Blended fat	3.0	—
Soybean meal	5.35	—
Cottonseed meal	—	4.0
Wheat middlings	1.20	—
Cane molasses	—	4.0
Urea	0.80	0.64
Limestone	1.00	0.69
Dicalcium phosphate	0.33	—
Salt	0.24	—[b]
Rumensin, 176 g/kg	0.02	0.02
Tylan, 88 g/kg	0.01	0.01
Vitamin A, 30,000 IU/g	0.01	0.01
Vitamin E, 500 IU/g	0.001	—
Trace mineral premix[a]	0.04	0.03
Calculated nutrient composition (DM basis)		
Crude protein, %	13.40	13.48
Dietary ME, Mcal/kg[c]	3.12	3.08
NE_m, Mcal/kg	2.15	2.11
NE_g, Mcal/kg	1.38	1.37

[a]Trace mineral composition: Zn, 13.5%; Mn, 6.0%; Cu, 3.6%; Fe, 1.43%; Co, 800 ppm; I, 6,000 ppm; Se,100 ppm.
[b]Salt offered free choice as a block.
[c]Dietary ME, NE_m, and NE_g values were calculated using the Level 1 Model (NRC, 1996).

Slaughter and Body Composition

Before placement in the feedlot for each experiment, four animals from each treatment were slaughtered for the determination of initial carcass characteristics and body composition. Steers were removed from their respective pastures at 0700 on the morning of slaughter and transported no more than 10 km to the Oklahoma Food and Agricultural Products Research and Technology Center abattoir. At slaughter, steers were stunned with a captive bolt gun and exsanguinated. Weights of the noncarcass tissues (blood, feet and ears, hide, all organs, and mesenteric fat; referred to herein as offal), digesta weights, and hot carcass weights (**HCW**) were recorded. Offal tissues (minus digesta) were composited and ground twice using an Autio grinder (Autio, Astoria, OR) through a 10-mm aperture plate, mixed, and subsampled in triplicate. After a 48-h chill, carcasses were reweighed and carcass characteristics that included maturity; fat thickness at the 12th rib; 12th-rib longissimus muscle area; kidney, pelvic, and heart (**KPH**) fat; marbling score; and quality grade were evaluated by Oklahoma State University meat science faculty. Carcass yield grades were calculated from carcass weight, fat thickness, KPH, and longissimus muscle area. The right side of each cold carcass was subsequently ground through a 10-mm followed by a 5-mm aperture plate, mixed, and subsampled in triplicate.

At final slaughter for each experiment, six steers from each treatment were selected for composition measurements (two steers/pen in Exp. 1). Final body composition procedures were the same as for the initial slaughter group. The remaining steers from each treatment were slaughtered, and carcass characteristics were measured as described for the initial slaughter.

Triplicate samples of carcass and offal were analyzed for water by lyophilization to a constant weight. Lyophilized carcass and offal samples were further processed to reduce particle size by submersion in liquid nitrogen and ground using a blender (Waring Products Co., Winsted, CT). Carcass and offal tissues were subsequently analyzed for fat (extraction with diethyl ether for 48 h in Soxhlet apparatus) and fat-free organic matter (**FFOM**; combustion of ether extraction residue, 500°C for 5 h). Energy content of carcass and offal tissues was calculated as weight of ether-extracted material × 9.40 kcal/g plus weight of FFOM × 5.55 kcal/g (Ferrell and Jenkins, 1998).

Calculations and Statistical Analysis

Dietary ME values were calculated using the Level 1 Model (NRC, 1996). Heat production (**HP**), as an estimate of maintenance energy requirement, was calculated using the equation HP (Mcal/d) = ME intake − retained energy (Lofgreen et al., 1963). Accretion of carcass and offal chemical components was calculated as the difference between the final individual weights and predicted initial weights of steers based on the composition of steers slaughtered at initiation of the finishing phase. Empty-body chemical composition was the sum of carcass and offal. Predicted initial composition weights were calculated using steers slaughtered before placement in the feedlot to calculate carcass and offal water, FFOM, fat, and energy contents on a live BW basis. The percentage was then multiplied by initial live BW of final slaughter steers to determine initial carcass and offal composition.

All data for finishing performance, carcass characteristics, chemical composition, and chemical accretion were analyzed as a completely random design using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). The statistical model for finishing performance and final carcass composition in Exp. 1 included the fixed-effect term for treatment and pen within treatment as the random effect. The statistical model for Exp. 2 finishing performance, carcass characteristics, chemical composition, and chemical accretion data and initial carcass characteristics and chemical accretion data in Exp. 1 included the fixed effect of treatment and steer within treatment as the random effect. Treatment least squares means were calculated and means compared using LSD when protected by a ($P < 0.10$) F-value. Pen was the experimental unit for finishing performance, feed intake, and final carcass data in Exp. 1, whereas steer was the experimental unit in Exp. 2. Steer was the experimental unit for all other measurements.

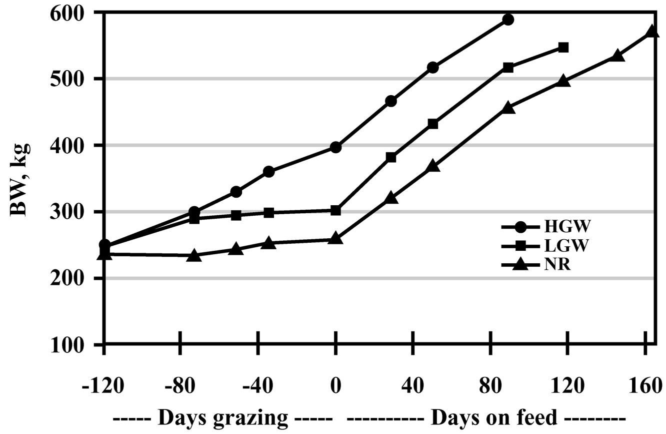

Figure 1. Steer live BW during winter grazing and the feedlot period in Experiment 1. HGW = high-gain wheat; LGW = low-gain wheat; NR = native range.

Results

Winter Grazing

Live BW of steers during winter grazing and the feedlot period are shown in Figures 1 and 2. In Exp. 1, both HGW and LGW steers gained BW at similar rates during the first 45 d, whereas the NR steers did not gain BW during this same period. During the last 74 d of the winter grazing period, LGW and NR steers gained 39 and 20 kg, respectively. In contrast, HGW steers gained 105 kg during the last 74 d of winter grazing. In Exp. 2, LGW and NR steers lost BW during the first 44 d, whereas HGW steers gained 21 kg. After d 45 of winter grazing in Exp. 2, HGW, LGW, and NR steers gained 1.49, 1.04, and 0.53 kg/d, respectively. Final grazing weights were greater for HGW than LGW steers, and both were heavier than NR steers in both experiments. Winter grazing ADG were 1.31, 0.54, 0.16, and 1.10, 0.68, 0.15 kg/d for HGW, LGW, and NR steers in Exp. 1 and 2, respectively. Total gastrointestinal tract fill at the end of winter grazing was not different ($P = 0.60$, 38.0 ± 4.8 kg, Exp. 1) among treatments. In Exp. 2, total gastrointestinal tract fill of NR steers (66 kg) was 18 and 20 kg greater ($P < 0.003$) than that of HGW and LGW steers.

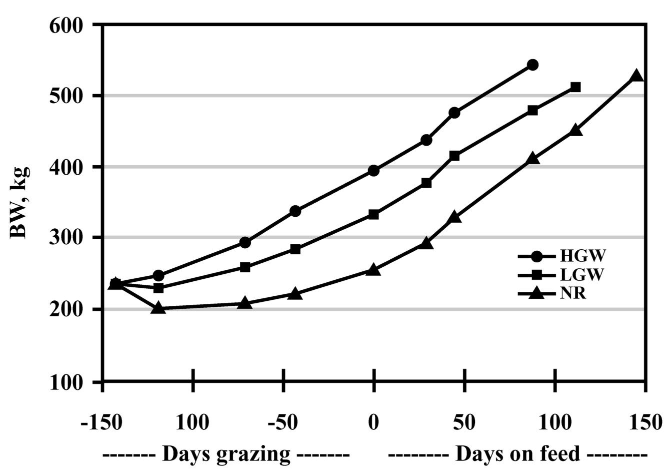

Figure 2. Steer live BW during winter grazing and the feedlot period in Experiment 2. HGW = high-gain wheat; LGW = low-gain wheat; NR = native range.

Finishing Performance

Experiment 1. Initial BW was 93 kg greater ($P < 0.001$) for HGW than for LGW steers and was 56 kg greater ($P < 0.001$) for LGW than NR steers (Table 2). Final BW of HGW and NR steers was 39 and 31 kg greater ($P < 0.02$) than LGW steers. Mean DMI was 10.4 kg/d and was not different ($P = 0.17$) among treatments. However, DMI (% of mean BW) of LGW and NR steers was greater ($P < 0.003$) than HGW steers. Live (average = 1.79 kg/d) and empty (average = 1.69 kg/d) BW gains were not different ($P = 0.43$) among treatments. Also, live gain efficiency did not differ ($P = 0.41$) among treatments.

Experiment 2. As in Exp. 1, initial BW was greatest ($P < 0.001$) for HGW, intermediate for LGW, and lowest for NR steers (Table 2). Final BW was greater ($P < 0.02$) for HGW than LGW; NR was intermediate. Similar to Exp. 1, mean DMI was 9.92 kg/d and was not different ($P = 0.40$) among treatments. However, DMI (% of mean BW) was the greatest for NR steers, being 14% greater ($P < 0.01$) than HGW steers but not greater ($P = 0.06$) than LGW steers. Daily live BW gains did not differ ($P = 0.24$; 1.68 kg/d) among treatments. Finishing empty BW gain was greater ($P < 0.02$) for NR than LGW steers and intermediate for HGW steers. Similar to Exp. 1, live gain efficiency was not different ($P = 0.58$) among treatments.

Carcass Characteristics

Experiment 1. Initial HCW of HGW steers was 64 and 100 kg greater ($P < 0.001$) than LGW and NR steers, respectively (Table 3). Initial dressing percent of HGW steers was 3.5 and 6.7 percentage units greater ($P < 0.001$) than LGW and NR steers. All initial measures of fat deposition (i.e., KPH fat, 12th-rib fat thickness, and marbling score) were greatest ($P < 0.001$) for HGW followed by LGW and then NR carcasses. The large initial differences in measures of fat deposition (i.e., body condition) were by experimental design. Final HCW was greater ($P < 0.03$) for HGW than LGW steers; HCW of NR steers was intermediate. All other final carcass measurements did not differ ($P = 0.12$) among treatments.

Experiment 2. Similar to Exp. 1, initial HCW of HGW steers was 48 and 93 kg greater ($P < 0.001$) than LGW and NR steers, respectively (Table 4). Dressing percent of HGW steers was 2.9 and 7.4 percentage units greater ($P < 0.001$) than LGW and NR steers. Similar to Exp. 1, all initial estimates of fat deposition were greater ($P <$

Table 2. Feedlot performance of steers from different winter grazing programs

Item	Treatment[a] HGW	LGW	NR	SEM[b]
	Experiment 1			
Initial feedlot live BW, kg	404[c]	311[d]	255[e]	2.4
Final feedlot live BW, kg	563[c]	524[d]	555[c]	7.1
Days on feed	89	116	163	—
Feed DMI				
kg/d	10.7	10.4	10.2	0.2
% of mean BW	2.21[c]	2.50[d]	2.40[d]	0.02
Gain, kg/d				
Live BW	1.79	1.80	1.82	0.06
Empty BW	1.64	1.67	1.75	0.06
Gain:feed				
Live	0.168	0.173	0.180	0.006
Empty	0.154	0.160	0.172	0.005
	Experiment 2			
Initial feedlot live BW, kg	395[c]	333[d]	257[e]	5.6
Final feedlot live BW, kg	542[c]	511[d]	528[cd]	9.9
Days on feed	85	111	158	—
Feed DMI				
kg/d	10.3	9.7	9.8	0.3
% of mean BW	2.19[c]	2.31[cd]	2.50[d]	0.07
Gain, kg/d				
Live BW	1.72	1.60	1.71	0.05
Empty BW	1.77[cd]	1.69[c]	1.86[d]	0.05
Gain:feed				
Live	0.176	0.169	0.178	0.006
Empty	0.181	0.179	0.194	0.006

[a]HGW = high-gain wheat; LGW = low-gain wheat; NR= native range. Mean live BW gain (kg/d) during winter grazing of HGW, LGW, and NR steers was, respectively, 1.31, 0.54, and 0.16 (Exp. 1) and 1.10, 0.68, and 0.15 (Exp. 2).
[b]Standard error of mean, Exp. 1 (n = 3); Exp. 2 HGW (n = 11), LGW and NR (n = 12).
[c,d,e]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 3. Effect of winter grazing on carcass characteristics of steers entering the feedlot and at final slaughter in Experiment 1

Item	Treatment[a] HGW	LGW	NR	SEM[b]
Initial slaughter				
Hot carcass wt, kg	237[c]	173[d]	137[e]	4.9
Dressing percent	60.4[c]	56.9[d]	53.7[e]	0.6
12th-rib fat thickness, cm	1.17[c]	0.25[d]	0.01[d]	0.10
Kidney, pelvic, heart fat, %	2.63[c]	0.50[d]	0.14[d]	0.22
Longissimus area, cm^2	70.5[c]	55.0[d]	47.3[d]	3.6
Marbling score[f]	357[c]	260[d]	155[e]	24.0
Yield grade	2.54[c]	1.59[d]	1.36[d]	0.26
Final slaughter				
Hot carcass wt, kg	342[c]	318[d]	329[cd]	3.7
Dressing percent	60.6	59.1	60.1	0.73
12th-rib fat thickness, cm	1.63	1.58	1.49	0.18
Kidney, pelvic, heart fat, %	2.19	1.72	1.64	0.18
Longissimus area, cm^2	77.2	76.5	82.3	3.66
Marbling score	448	392	399	25.9
Yield grade	3.49	3.24	3.02	0.23

[a]HGW = high-gain wheat; LGW = low-gain wheat; NR= native range.
[b]Standard error of mean, n = 4 for initial slaughter; n = 3 for final slaughter.
[c,d,e]Within a row, means without a common superscript letter differ ($P < 0.05$).
[f]100 = practically devoid, 200 = trace, 300 = slight, 400 = small.

Table 4. Effect of winter grazing on carcass characteristics of steers entering the feedlot and at final slaughter in Experiment 2

	Treatment[a]			
Item	HGW	LGW	NR	SEM[b]
Initial slaughter				
Hot carcass wt, kg	225[c]	177[d]	132[e]	5.89
Dressing percent	59.7[c]	56.8[d]	52.3[e]	0.67
12th-rib fat thickness, cm	0.69[c]	0.08[d]	0.01[d]	0.06
Kidney, pelvic, heart fat, %	2.25[c]	1.31[d]	0.88[e]	0.21
Longissimus area, cm^2	56.7	55.6	47.4	2.9
Marbling score[f]	275[c]	75[d]	0.0[e]	17.2
Yield grade	2.76[c]	1.58[d]	1.43[d]	0.16
Final slaughter				
Hot carcass wt, kg	328	308	320	6.9
Dressing percent	60.4	60.9	60.7	0.60
12th-rib fat thickness, cm	1.37	1.16	1.55	0.13
Kidney, pelvic, heart fat, %	1.82	1.83	1.67	0.09
Longissimus area, cm^2	79.3	74.6	74.2	2.4
Marbling score	405	387	426	16.6
Yield grade	3.01	3.02	3.38	0.17

[a]HGW = high-gain wheat; LGW = low-gain wheat; NR= native range.
[b]Standard error of mean, n = 4 for initial slaughter; HGW (n = 11), LGW and NR (n = 12) for final slaughter.
[c,d,e]Within a row, means without a common superscript letter differ (P < 0.05).
[f]0 = devoid, 100 = practically devoid, 200 = trace, 300 = slight, 400 = small.

0.004) for HGW carcasses than LGW and NR carcasses. Like Exp. 1, the large initial differences in measures of fat deposition were by experimental design. All final carcass measurements did not differ (P = 0.11) among treatments.

Carcass Chemical Composition

Experiment 1. Initial carcass mass, mass of FFOM and fat, energy content, and proportion of fat (g/kg of carcass) were greatest (P < 0.001) for HGW, intermediate for LGW, and lowest for NR steers (Table 5). Initial proportions of carcass FFOM were not different (P = 0.50) among treatments. Initial offal mass was greatest (P < 0.001) for HGW, intermediate for LGW, and lowest for NR steers. Initial FFOM mass and proportion of FFOM in offal were not different (P = 0.18) among treatments. Initial fat mass and proportion and energy content of offal followed a pattern similar to that of carcass fat and energy, and were greatest (P < 0.001) for HGW, followed by LGW, and then NR steers. Initial empty-body and FFOM mass, fat mass and proportion, and energy content were greatest (P < 0.001) for HGW, intermediate for LGW, and lowest for NR steers. The proportion of FFOM in empty body was not different (P = 0.46) among treatments.

At final slaughter, carcasses of HGW and NR steers were heavier (P < 0.05), contained more fat (P < 0.03), and had a greater proportion of fat (P < 0.05) and more energy (P < 0.03) than LGW steers. Final carcass water and FFOM were not different (P = 0.38) among treatments. Final offal mass and final proportions of offal FFOM and fat, and energy content of offal were not different (P = 0.11) among treatments. Final empty-body mass of HGW and NR was greater (P < 0.03) than LGW steers. Because of the relatively small differences among treatments for carcass and offal weight and chemical content, empty-body chemical composition was not different (P = 0.25) among treatments except for final fat mass and empty-body energy content, which was greater (P < 0.04) for HGW and NR than LGW steers.

Rates of carcass mass (average = 1.28 kg/d), water, and fat accretion were not different (P = 0.14) among treatments during the finishing period (Table 5). Accretion of carcass FFOM was greater (P < 0.004) for LGW than for both HGW and NR steers. Carcass energy accretion did not differ (P = 0.69) among treatments. Offal mass, water, fat, and energy accretion did not differ (P = 0.19) among treatments. Offal FFOM accretion was greater (P < 0.02) for HGW than for both LGW and NR steers. Empty-body mass, FFOM, fat accretion, and energy content were not different (P = 0.22) among treatments. However, calculated empty-body HP ($Mcal \cdot d^{-1} \cdot 100$ kg EBW^{-1}) of LGW and NR steers was 14% greater (P < 0.02) than HGW steers.

Experiment 2. Initial carcass, offal, and empty-body masses were greatest (P < 0.001) for HGW, intermediate for LGW, and lowest for NR steers (Table 6). Carcass water and fat mass, and energy content were greater (P < 0.001) for HGW than LGW, and carcass water and fat mass and energy content were greater (P < 0.001) for LGW than NR steers. However, the proportions of FFOM in carcasses of LGW and NR steers were greater (P < 0.01) than HGW. Offal water and fat mass and proportion of fat in offal were greater (P < 0.002) for HGW than LGW, which was greater than NR steers. The proportion of FFOM in offal was not different (P =

Table 5. Effect of winter grazing program on chemical composition (Experiment 1)

	Carcass				Offal				Empty body			
	Treatment[a]				Treatment				Treatment			
	HGW	LGW	NR	SEM[b]	HGW	LGW	NR	SEM	HGW	LGW	NR	SEM
Initial												
Mass, kg[c]	237.2^{d}	172.6^{e}	137.0^{f}	5.15	117.7^{d}	90.7^{e}	70.3^{f}	2.44	354.9^{d}	263.3^{e}	207.4^{f}	6.47
Water, kg	127.7^{d}	107.8^{e}	95.0^{f}	2.97	70.4^{d}	58.5^{e}	49.0^{f}	2.06	198.2^{d}	166.3^{e}	143.9^{f}	5.54
FFOM, kg[g]	53.6^{d}	37.5^{e}	29.6^{f}	1.86	21.7	19.2	16.7	2.17	75.3^{d}	56.7^{e}	46.4^{f}	2.50
FFOM, g/kg	225.5	215.6	216.6	6.21	183.4	212.9	239.1	19.29	210.8	214.8	224.4	7.57
Fat, kg	49.2^{d}	24.8^{e}	10.2^{f}	1.93	24.0^{d}	11.4^{e}	3.5^{f}	1.20	73.1^{d}	36.2^{e}	13.8^{f}	2.40
Fat, g/kg	207.4^{d}	143.1^{e}	74.3^{f}	10.33	204.1^{d}	125.0^{e}	49.0^{f}	12.71	207.6^{d}	136.2^{e}	65.8^{f}	8.38
Energy, Mcal[h]	759^{d}	441^{e}	261^{f}	20	346^{d}	214^{e}	126^{f}	9	$1,104^{d}$	655^{e}	387^{f}	27
Final												
Mass, kg[c]	339.1^{d}	317.2^{e}	337.4^{d}	6.27	161.2	151.2	162.5	3.86	500.2^{d}	468.4^{e}	500.0^{d}	8.53
Water, kg	166.5	166.2	169.3	4.14	89.3	85.1	93.4	2.51	255.8	251.4	262.8	5.58
FFOM, kg	66.3	63.9	63.3	1.52	33.9	30.9	33.1	1.35	100.3	94.9	96.4	2.23
FFOM, g/kg	195.5	201.9	187.8	4.01	211.0	204.6	203.7	7.13	200.5	202.7	193.0	4.40
Fat, kg	99.2^{d}	82.0^{e}	98.7^{d}	4.69	35.3	33.3	33.8	2.30	134.5^{d}	115.3^{e}	132.5^{d}	5.86
Fat, g/kg	292.7^{d}	258.4^{e}	291.9^{d}	11.58	219.2	220.2	207.6	13.19	268.9	246.4	264.4	10.46
Energy, Mcal	1301^{d}	1126^{e}	1280^{d}	46	521	485	501	20	$1,821^{d}$	$1,611^{e}$	$1,781^{d}$	54
Accretion[i]												
Mass, kg/d[c]	1.27	1.33	1.23	0.04	0.55	0.57	0.56	0.03	1.83	1.91	1.79	0.05
Water, g/d	506	568	454	38	250	265	272	20	755	833	726	50
FFOM, g/d	173^{d}	250^{e}	206^{d}	14	150^{d}	111^{e}	100^{e}	12	323	361	305	22
Fat, g/d	589	501	543	37	140	194	186	21	730	695	729	50
Energy, Mcal/d	6.50	6.10	6.25	0.33	2.15	2.44	2.30	0.18	8.65	8.54	8.55	0.50
Heat production, mcal·d^{-1}·100 kg EBW^{-1}[j]	—	—	—	—	—	—	—	—	5.63^{d}	6.42^{e}	6.42^{e}	0.17

[a]HGW = high-gain wheat; LGW = low-gain wheat; NR= native range.
[b]Standard error of mean, n = 4 for initial slaughter, n = 6 for final slaughter and accretion.
[c]Hot carcass weight.
[d,e,f]Within a row and tissue, means without a common superscript letter differ ($P < 0.05$).
[g]Fat-free organic matter.
[h]Ether extract material × 9.4 kcal/g + fat-free organic matter × 5.55 kcal/g.
[i]Final, kg – predicted initial, kg/days on feed.
[j]Mean empty – body weight.

0.52) among treatments. Because of large differences in the fat content of offal, the energy content of HGW offal was greater ($P < 0.001$) than that of LGW, and LGW was greater ($P < 0.001$) than NR. Empty-body water, FFOM, and fat mass and energy content were greatest ($P < 0.002$) for HGW, intermediate for LGW, and lowest for NR steers. However, the proportion of empty-body FFOM was greater ($P < 0.02$) for both LGW and NR than HGW steers.

Final carcass mass, FFOM mass and proportion, and energy content were not different ($P = 0.17$) among treatments. Final fat mass of NR carcasses was 10.1 kg greater ($P < 0.04$) than HGW, whereas final fat mass of LGW steers was intermediate. The final proportion of the fat of LGW and NR steers was greater ($P < 0.03$) than HGW. Final offal mass, water, and FFOM was not different ($P = 0.45$) among treatments. Final fat mass and proportion and energy content of offal were greater ($P < 0.05$) for NR than HGW steers. Final empty-body mass was not different ($P = 0.43$) among treatments. The only difference in chemical composition of final empty body was an increased ($P < 0.02$) proportion of fat for both NR and LGW steers compared with HGW.

Rates of carcass mass (1.20 kg/d) and FFOM accretion were not different ($P = 0.22$) among treatments during the finishing period (Table 6). Carcass water accretion was greater ($P < 0.05$) for HGW and NR than LGW steers. Accretion of carcass energy by LGW and NR steers was, respectively, 1.08 and 0.96 Mcal/d greater ($P < 0.03$) than HGW steers because of greater ($P < 0.02$) carcass fat accretion. Offal water and FFOM accretion was not different ($P = 0.50$) among treatments. Fat accretion in offal was greater ($P < 0.05$) for LGW and NR than HGW steers, resulting in greater ($P < 0.03$) energy accretion by LGW and NR steers. Accretion of empty body mass by NR steers was greater ($P < 0.02$) than HGW steers; LGW steers were intermediate. Accretion of empty-body FFOM did not differ ($P = 0.48$) among treatments. Empty-body fat accretion was greater ($P < 0.003$) for LGW and NR than HGW steers. Empty-body energy accretion by LGW and NR steers was, respectively, 1.51 and 1.40 Mcal/d greater ($P < 0.01$) than HGW steers. Similar to Exp. 1, the HP of NR steers was increased 17% compared with HGW; however, the HP of LGW steers was not different ($P = 0.27$) than that of HGW.

Discussion

Our goal was to use grazing programs that are widespread in the southern Great Plains to establish differ-

Table 6. Effect of winter grazing program on chemical composition (Experiment 2)

	Carcass				Offal				Empty body			
	Treatment[a]				Treatment				Treatment			
	HGW	LGW	NR	SEM[b]	HGW	LGW	NR	SEM	HGW	LGW	NR	SEM
Initial												
Mass, kg[c]	225.5[d]	177.5[e]	132.0[f]	5.90	111.7[d]	96.3[e]	73.0[f]	3.46	337.2[d]	273.8[e]	205.0[f]	8.45
Water, kg	126.8[d]	109.5[e]	91.3[f]	4.52	70.3[d]	62.8[e]	53.1[f]	2.43	197.1[d]	172.2[e]	144.4[f]	5.65
FFOM, kg[g]	48.1[d]	42.0[ef]	32.1[f]	2.06	22.9[d]	20.3[d]	16.0[e]	1.18	71.0[d]	62.3[e]	48.1[f]	2.72
FFOM, g/kg	212.8[d]	236.4[e]	243.3[e]	5.84	205.2	209.8	220.3	9.28	210.5[d]	227.0[e]	235.0[e]	5.20
Fat, kg	45.8[d]	22.8[e]	6.4[f]	2.50	16.8[d]	11.5[e]	2.8[f]	0.97	62.6[d]	34.3[e]	9.2[f]	3.11
Fat, g/kg	204.5[d]	128.5[e]	47.6[f]	13.75	150.4[d]	119.6[e]	38.3[f]	8.2	186.1[d]	125.2[e]	44.2[f]	10.02
Energy, Mcal[h]	697[d]	441[e]	238[f]	24	285[d]	221[e]	115[f]	12	983[d]	668[e]	354[f]	34
Final												
Mass, kg[c]	323.8	313.8	329.5	7.77	155.0	156.5	158.0	3.16	478.8	470.3	487.4	9.13
Water, kg	168.7	157.5	167.1	4.30	89.2	85.9	87.5	1.82	258.0	243.4	254.6	4.97
FFOM, kg	66.9	63.1	64.2	2.07	29.7	29.8	29.7	1.51	96.6	92.9	93.9	2.83
FFOM, g/kg	206.6	200.9	194.9	4.17	191.5	190.3	188.2	8.35	188.7	197.4	192.8	7.06
Fat, kg	81.8[d]	86.9[de]	91.9[e]	2.89	32.6[d]	37.5[de]	38.9[e]	1.80	114.5	124.4	130.8	4.31
Fat, g/kg	252.7[d]	277.3[e]	278.8[e]	6.88	211.2[d]	239.3[de]	245.4[e]	10.43	239.2[d]	264.4[e]	268.1[e]	7.07
Energy, Mcal	1140	1167	1221	33	472[d]	517[de]	530[e]	16	1,612	1,685	1,751	43
Accretion[i]												
Mass, kg/d[c]	1.15	1.19	1.27	0.05	0.50[d]	0.52[d]	0.60[e]	0.03	1.63[d]	1.71[de]	1.98[e]	0.06
Water, g/d	487[e]	407[d]	494[e]	27	219	195	227	20	698[de]	602[d]	786[e]	35
FFOM, g/d	214	181	209	17	79	82	97	14	283	263	297	21
Fat, g/d	425[d]	573[e]	543[e]	27	186[d]	231[e]	229[e]	15	611[d]	804[e]	722[e]	37
Energy, Mcal/d	5.31[d]	6.39[e]	6.27[e]	0.27	2.20[d]	2.63[e]	2.64[e]	0.12	7.51[d]	9.02[e]	8.91[e]	0.35
Heat production, mcal·d^{-1}·100 kg EBW^{-1}[j]	—	—	—	—	—	—	—	—	5.79[d]	5.50[d]	6.76[e]	0.28

[a]HGW = high-gain wheat; LGW = low-gain wheat; NR= native range.
[b]Standard error of mean, n = 4 for initial slaughter, n = 6 for final slaughter and accretion.
[c]Hot carcass weight.
[d,e,f]Within a row and tissue, means without a common superscript letter differ ($P < 0.05$).
[g]Fat-free organic matter.
[h]Ether extract material × 9.4 kcal/g + fat-free organic matter × 5.55 kcal/g.
[i]Final, kg – predicted initial, kg/days on feed.
[j]Mean empty – body weight.

ent rates of gain during the growing phase and then evaluate the effect of previous rate of BW gain and body condition on subsequent finishing performance, carcass merit, body chemical composition, and accretion rates. Across an average of 132 d (Exp. 1 and 2), BW gain for HGW steers was 77 kg more than LGW and 143 kg more than NR steers. Increased daily gain for calves grazing winter wheat compared with dormant native grass plus protein supplement has previously been reported (Phillips et al., 1991, 2001). In our experiments, differences in BW gain during the grazing phase resulted in differences in carcass characteristics and empty-body composition of steers at the beginning of the finishing period. Carcass, offal, and whole body fat analysis, plus indirect measures of fat content from carcass characteristics, indicated that HGW steers entered the finishing phase with greater body fat than LGW steers, and that LGW had greater body fat than NR steers. Initial carcass fat averaged 206, 136, and 61 g/kg of carcass mass for HGW, LGW, and NR, respectively. Baker et al. (1992) fed silage-based diets to steers at restricted-fed and ad libitum-fed levels of intake, and they reported that restricted steers had 34% less empty-body fat and 0.33 Mcal/kg less body energy compared with ad libitum-fed steers. In addition, restricted steers had 8% more protein and 6% more empty-body water compared with ad libitum steers. Sainz et al. (1995) reported that carcass and empty-body fat of steers fed concentrate ad libitum was greater than steers limit-fed concentrate or forage-fed steers but that empty-body protein mass was greater in the limit-fed and forage-fed steers. Our data is similar in that initial empty-body fat and energy content of HGW steers was increased and empty-body FFOM content was decreased compared with LGW and NR steers.

Our objective was to slaughter steers at the end of the finishing phase at a common compositional end point. Grazing program did affect marbling score before finishing. The initial differences in marbling scores were likely related to differences in energy intake and thus fat deposition during grazing. Similar differences in marbling score have been observed between ad libitum-fed and restricted-fed steers (Sainz et al., 1995). However, when steers were finished to a common backfat end point, no differences in marbling score remained between treatments. Drouillard et al. (1991b), Sainz et al. (1995), and White et al. (1987) reported no differences in final marbling score when cattle from a variety of growing programs, which produced different BW gains before feedlot finishing, were slaughtered at a common end point. In our study, there were no differences in final empty-body chemical composition and energy content except for slight differences in energy content of LGW steers in Exp. 1. This is consistent with previous work (Coleman et al., 1993; Hayden et al., 1993; Sainz et al., 1995) reporting no differences between control and previously restricted steers for final empty-body composition.

Although there were no differences in finishing performance among the steers in our treatments, an increase in feedlot performance of the LGW and NR steers, relative to HGW steers, would typically be expected. Carstens et al. (1991) reported that steers that exhibited compensatory growth after a 189-d restriction period, in which they gained 0.4 kg/d, had ADG that was 37% greater than ad libitum-fed control steers. In an experiment by Wright and Russel (1991), Charolais-cross steers that had been restricted to 58% of the daily gain of control steers from 259 to 350 kg of BW, gained 38% faster from 350 to 400 kg while consuming similar amounts of feed compared with control steers. This resulted in an improved gain efficiency of 39% for compensating steers. Similar to our results, White et al. (1987) reported that steers that had the highest BW gains on winter wheat pasture also had the greatest BW gains during the first 28 d of a subsequent summer grazing period or feedlot finishing period, but gains for the entire finishing period did not differ from steers that had lower BW gains on winter wheat pasture.

The absence of differences in finishing performance between the three treatment groups in our study is in contrast with current industry dogma and the Level 1 Model of the 1996 Beef Cattle NRC, which results in a negative relationship between predicted ME allowable ADG and initial body fat content of growing/finishing cattle. For the past 10 yr, we have obtained feedlot performance data on all of the steers that have grazed wheat pasture for various experiments. The data set consists of 25 pens (50 to 210 steers/pen) with initial on-feed BW and feedlot ADG that ranges, respectively, from 257 to 443 kg (mean = 360 kg) and from 1.49 to 1.95 kg/d (mean = 1.67 kg/d). Regression analysis corrected for year showed that feedlot ADG was not related ($P < 0.25$) to linear or quadratic effects of initial weight even though there was a substantial range in initial weight and body condition of these steers. Regression coefficients for the linear and quadratic effects of initial weight were 0.0073 and –0.000004, respectively. Although price discounts (dollars per unit weight basis) for feeder cattle with greater body condition are common in the industry (Smith et al., 1998, 2000; Mintert et al., 1988), our data indicate that price discounts for heavier feeder cattle coming off wheat pasture may not be justified in relation to their subsequent finishing performance.

Sainz et al. (1995) reported that increased feed DMI accounted for 60 to 104% of the increased growth rate during finishing of previously restricted steers and that energy restriction decreased maintenance energy requirements of steers limit-fed a high-concentrate diet but increased maintenance energy requirements of steers fed an alfalfa/oat straw-based diet. Feed intake, expressed as a percentage of mean weight, of LGW and NR steers was greater compared with HGW steers in our study. However, neither live- nor empty-BW ADG of LGW and NR steers were increased during finishing. The increased feed DMI and increased HP of NR steers in our study are similar to results of Sainz et al. (1995) for steers fed the alfalfa/oat straw-based diet. The lack of increased BW ADG of LGW and NR steers relative to HGW steers could be due to the increased HP. However, a consistent effect of grazing program on HP of LGW steers during finishing was not observed. Calculated HP of NR steers during finishing in Exp. 1 and 2, and LGW steers in Exp. 1 were about 15% greater than HGW steers. Consumption of low-quality, dormant native range forage by steers during the winter growing program increased their maintenance energy requirements during the subsequent finishing phase of both experiments. Blum et al. (1985) examined changes in heat production during and immediately after energy restriction of 2-yr-old steers. At the end of a 151-d restriction phase, heat production by restricted steers was 100 $kcal \cdot kg^{-0.75} \cdot d^{-1}$. However, by the fifth day of refeeding, heat production by previously restricted steers had increased to 148 $kcal/(kg^{0.75} \cdot d)$ and remained constant through d 24 of realimentation.

Ferrell and Jenkins (1984) reported that ME requirements for maintenance were less for lean cows than for fat cows when differences in fatness within genetically similar cows were due to previous nutritional manipulation. Our HGW steers were fatter than LGW and NR steers when placed on feed. Fox et al. (1972) concluded that NE_m and NE_g values of diets are not independent of the previous nutritional treatment of cattle. Whereas differences in empty-body fat accretion for LGW and NR vs. HGW steers were not consistent between our experiments, Drouillard et al. (1991b) reported that energy-restricted lambs deposited more fat during the early finishing period and speculated that the growth potential of the lambs had been compromised. Whether the lack of increased growth of LGW and NR steers during finishing in our study was due to increased maintenance energy requirements or compromised growth potential is not clear. Potential mechanisms are addressed in our companion paper (Hersom et al., 2004).

Implications

Feeder cattle with high body condition resulting from grazing or growing programs have traditionally been discounted in price because of anticipated decreased performance during the finishing phase of production. Our data indicate that this may not be valid for high-gaining wheat pasture cattle. Similar feedlot gains by high-gaining wheat pasture cattle may partially be due to lower maintenance energy requirements compared with lower-gaining or nutritionally restricted cattle from other grazing programs. Ad libitum intake of low-quality forages by growing cattle may increase maintenance energy requirements to an extent that potentially increased feed intake during feedlot finishing is negated. Although mechanisms need to be elucidated, our data show that differences in initial body composition of cattle when placed on feed can be effectively mitigated when they are fed to the same compositional end point.

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